Geological Investigations Of Quaternary Deformation And Implications For Blind Fault Activity, Northern Los Angeles Basin (Collaborative Research Gorian And Associates, Inc. And United States Geological Survey)

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INVESTIGATION

This investigation models Quaternary deformation in an area postulated to be undergoing uplift and folding by active "blind" faulting in the northern Los Angeles basin. Our area of study, the La Brea Plain, is a dissected Pleistocene alluvial surface wedged between the right-lateral Newport-Inglewood fault zone to the west and the left-oblique Hollywood fault on the north (Figure 1). Beneath the plain, oil-industry subsurface exploration has illuminated a south-southwest facing monocline involving late Tertiary strata that is complicated by secondary folds and faults (Jacobson and Lindblom, 1977; Wright, 1991). Recently, several workers (Davis et al., 1989; Shaw and Suppe, 1996; Schneider et al., 1996) have used this stratigraphic and structural data to develop several contrasting blind fault models for the area. In addition, Hummon et al, (1994), using the same dataset, proposed an active, shallow, low angle, north-dipping blind-thrust fault to account for the apparent anticlinal warp (the Wilshire arch) in the base of a section of near-surface clastic "Quaternary" sediments. Taken as a whole these blind-fault models predict late Tertiary to Recent uplift rates in the La Brea Plain of ~0.26-1.1 mm/yr or greater, and N-S shortening on the order of 1-4 mm/yr.

Unfortunately, the oil-industry data are lacking chronological and structural information from the Quaternary section that are necessary to validate and constrain these structural models for use in evaluating present-day seismic hazards. In 1996, we began to fill this gap by collecting and analyzing continuous cores from four drill holes along a 260 m-long east-west profile in the Hancock Park area (Quinn, et al., 1997; Ponti et al., in prep), which is situated near the crest of the arch. We have used amino-acid geochronology, paleomagnetism, tephra analysis, and paleoenvironmental analysis of molluscan macrofauna, coupled with the marine isotope climatic model and sequence stratigraphy concepts, to develop a chronostratigraphic framework for the Quaternary sediments in this area. The results of this effort indicated that the rate of uplift at Hancock Park, averaged over the last ~800 ka is ~0.13-0.16 mm/yr, significantly less than predicted by any of the structural models used to develop fault activity estimates for the northern Los Angeles basin. Furthermore, our initial work suggested that Quaternary deformation might not be mimicking the folding observed in the late Tertiary section (upon which the structural models are based).

In order to develop a fuller understanding of the nature of Quaternary deformation in the area, we are presently developing a three-dimensional stratigraphic and structural model of the La Brea Plain. The cornerstone of this model is the detailed Quaternary litho- and chronostratigraphic model that we developed at Hancock Park (Quinn, et al., 1997; Ponti et al., in prep). There we observe an eastward-thinning sequence of three major mid-early Pleistocene transgressive marine units that onlap dipping Tertiary rocks. The sequence consists of a ~800 ky old basal silt (age based on the presence of the Brunhes-Matuyama magnetic reversal boundary) unconformably overlain by two transgressive shallow-water marine sands that we presently correlate with the ^{18}O stages 13-11 (~620-390 ka) and 9 (~320 ka) sea-level highstands, respectively. The marine sequence has been subsequently buried by 13-16 m of mid-late Pleistocene continental (primarily fluvial) sediments.

We are extending this model by collecting additional subsurface information (geotechnical boring logs) from numerous localities in the La Brea area (Figure 2). At present, the logs of 299 borings have been coded into a spatial database (TechBase). Intersecting cross-sections have been prepared that allow correlation to the stratigraphy previously developed for Hancock Park. In addition, 37 core boxes, 181 Shelby tube cores, 646 ring-lined cores, 279 SPT samples, and other samples have been acquired for this study (delays in acquiring critical samples required extending the period of this investigation). Consultants, as part of geotechnical investigations for the Los Angeles MetroRail project, originally collected these well-documented samples. The samples are being used to evaluate log descriptions and selected samples are being analyzed to identify the Brunhes-Matuyama paleomagnetic boundary, Bishop ash, Lava Creek ash, ^{18}O isotope stage 13-11 erosional platform, and ^{18}O isotope stage 9 highstand deposits recognized at Hancock Park. The first phase of sample analyses involves paleomagnetic analysis of 70 oriented samples. Results of these analyses will be used to guide additional work.

RESULTS

Preliminary work has required minor revisions to our previous interpretation of the Hancock Park profile (Figure 3). The oldest Quaternary unit (unit 1) was originally interpreted as a westward thickening wedge of onlapping marine sediments that spanned the Brunhes-Matuyama boundary (~780 ka) and thus was deposited during the ^{18}O isotope stage 20-19 marine transgression. Subsequently, the Lava Creek ash (~665 ka) has been identified from the upper part of unit 1 from one of our borings. Therefore, unit 1 does not represent a single transgressive depositional episode, but at least two such episodes. We have now divided unit 1 into subunits 1A and 1B, that reflect deposition during the ^{18}O isotope stage 20-19 and ^{18}O isotope stage 16-15 transgressions, respectively. Additional complicating factors were introduced by correlations with other borings and the geometric constraints imposed by lithologic correlations. Unit 1A is, at present, not clearly distinguishable lithologically or faunally from sediments referred to the Fernando Formation in adjacent borings. Geometric constraints suggest that unit 1A is present either as a channel inset, or may actually be a part of the underlying Fernando Formation, making the Fernando in part as young as mid-Pleistocene. Since the Fernando Formation is locally tilted about 15°, regional tilting may have continued at least into the middle Pleistocene. Unit 1B now appears to represent a discrete channel inset deposit based on correlation with several borings. Inclination of unit 1B bedding has not yet been established.

Unit 2 consists of two transgressive marine units (2A and 2B) that are superposed in the Hancock Park profile (Figure 3). The base of unit 2 represents a marine abrasion platform that is clearly recognized where developed on the Puente Formation from the area of Hancock Park eastward to Normandie Avenue (Figure 2). West of Hancock Park, where the base of unit 2 extends across the Fernando Formation or older Pleistocene sediments, the contact is not as sharply defined, but is distinguished by a basal lag deposit. Figure 4, an E-W cross-section along Wilshire Blvd. between Fairfax and Normandie Avenues, shows the abrasion platforms corresponding to units 2A and 2B to be nearly flat lying and not progressively tilted as are the underlying Tertiary units. This provides compelling evidence that SW-tilting of this part of the La Brea plain ceased or significantly slowed by ^{18}O stage 13-11 (~530-420 ka). The shoreline angles for units 2A and 2B have been tentatively identified in the Wilshire section (Figure 4) and we are presently exploring their geometries. Elevations of the shoreline angles place tighter constraints on the rate of uplift of the La Brea Plain, now determined to be 0.11-0.13 mm/yr

Additional analyses are in progress that will illuminate the structural and temporal relationships of the Quaternary deposits of the La Brea Plain. A combination of micro- and macropaleontologic determinations, strontium isotope (^{87}Sr/^{86}Sr) ratios, paleomagnetic, and tephra analyses of existing samples are expected to help distinguish unit 1 and Fernando Formation sediments. Additional macropaleontologic determinations and amino-acid racemization analyses of existing samples are expected to better define transgressive sequences within unit 2 and help correlate unit 2 deposits in the region. We also are acquiring additional geotechnical boring logs and will integrate oil industry logs into our spatial data base that will extend our current area of coverage. These additional analyses and boring logs are expected to provide a chronologically constrained model of Quaternary deformational patterns in the La Brea area.

NON-TECHNICAL SUMMARY

This investigation models Quaternary deformation in an area postulated to be undergoing uplift and folding by active “blind” faulting in the northern Los Angeles basin. The model of Quaternary deformation is being developed, through a multi-disciplinary approach using existing subsurface information (boring logs) and samples, to constrain structural models used in evaluating present-day seismic hazards. Preliminary results indicate that the rate of uplift of the La Brea area averaged over the last ~800 ka is ~0.11-0.13 mm/yr, significantly less than predicted by any of the structural models used to develop fault activity estimates for the northern Los Angeles basin.

PUBLICATIONS

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AVAILABILITY OF DATA

Once completed, we intend to post the La Brea borings spatial data base on a web site maintained by the USGS.